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Review Article: Silicate Bacteria as a Biofertilizer

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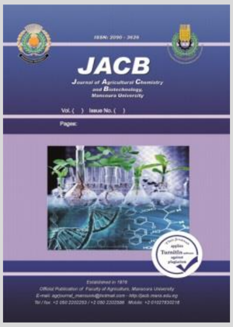

ABSTRACT

The present article reveals that silicate solubilizing microbes are essential part of weathering silicate minerals. Alumino-silicate group appears the most minerals to weathering by several bacteria. The contribution of biological agents in weathering has attracted increased interests as several genera of microorganisms, therefore referred as "silicate bacteria" were found to decompose aluminosilicate minerals to increase potassium, silicon and aluminum in an available forms for plant nutrition.Thus, the magnitude of the role of such bacteria in the decomposition of alumino-silicates and releasing the elements contained therein as well as in the elements uptake by plants was found of great interest . The article concluded that effect of silicate bacteria in minerals weathering, soil formation, elements cycling and plant nutrition. Therefore, the speculate that the classic weathering sequence is not just chemical weathering. But should be interpreted as a mixture of chemical and biochemical weathering.

Keywords: Silicate bacteria; Silicate minerals; Biofertilizers.

INTRODUCTION

Microorganisms increase the availability of plant elements nutrition by increasing the amounts, concentration, and properties of elements available to plants. These availability lead to increase in the growth, enhancement and chemical composition of plants that are common and substantial enough to encourage the exploitation of plant-microbe interactions for development of crop quality. Possible approaches include both introduction of foreign rhizobacteria and capitalization on the indigenous microflora. These microorganisms are especially great in situation in which the supply of minerals is limiting for plant growth. Silicate weathering as a part of soil formation occurs through inorganic and organic chemical reactions in parent materials and soils, which are mostly alimino-silicates. The bulk of mineral elements in these alumino-silicate consist of: potassium, silicon and aluminum (Diest, 1978). The degradation of such silicate minerals will eventually release these elements. The contribution of biological agents in weathering has attracted increased interests as several genera of microorganisms, therefore referred as " silicate bacteria" were found to decompose aluminosilicate minerals to increase potassium, silicon and aluminum in an available forms.Thus, the magnitude of the role of such bacteria in the decomposition of alumino-silicates and releasing the elements contained therein as well as in the elements uptake by plants (Afify,1982) was found of great interest. The article concluded that effect of silicate bacteria in minerals weathering, soil formation, elements cycling and plant nutrition. Therefore, the speculate that the classic weathering sequence is not just chemical weathering. But should be interpreted as a mixture of chemical and biochemical weathering. However, little is known about the effect of such bacteria and silicate minerals.

History of silicate bacteria

The silicate minerals can be attacked through the products of metabolism of microorganisms as was early demonstrated by Bassalik 1912 & 1913 (Cited in webley *et al.*,1963) and Thiel (1927). Brussoff (1933) has isolated a theremophilic *B.siliceus*, which abundantly deposited silicon in its cells. However, the existence of "silicate bacteria" defined as chemolitho-autotrophic bacteria, that gain their energy by deterioration of Si-O bonds in silicates, which have been suspected by Vernadsky (1954). Conversely, Heinen (1978) was able to show that silicon is actively metabolized by several bacteria. In Egypt, little attention has been paid to the effect of silicate bacteria on the uptake of nutrients elements mainly K and Si (Zahra, 1969; Saber and El-Sherif, 1975; Saber *et al.*, 1975; Heggo, 1978; Saber and Zanati 1981; Afify 1982; Zahra *et al.*, 1984; Balabel 1997; Afify and Bayoumy 2001; Hauka *et al.*, 2017 and Afify *et al.*, 2018).

Silicate bacteria and weathering of silicate minerals

The production of acids by microorganisms are living on the stone seems to be the most important deteriorating agent (Fig. 1 and 2). Organic acids such as oxalic, citric or gluconic acids, excreted by heterotrophic bacteria and fungi, are thought to be more important weathering agents (Heggo,1978). The efficiency of silicate bacteria i.e. two strains of *B. circulans* and one strain of *Arthrobacter tumescens* in potassium mobilization from certain alumin-silicates: (orthoclase, microcline, mica-mucovite and nile silt). Inoculation with these silicate bacteria, evidently accelerated the weathering of minerals tested, mobilizing great amounts of potassium (Shady, *et al.*1983). Incubation of moist silicate minerals with silicate bacteria aseptically led to progressive increase in amounts of soluble and amorphous silica due to physical and chemical weathering. Release of water-soluble silica followed the order: micamuscovite > nile silt > microcline > orthoclase. The changes in amounts of soluble and amorphous aluminum were largest for muscovite and smallest for silt. Nitrogen amendment had a favourable influence on the dissolution of all the silicate minerals (Mansour, *et al.*, 1984).

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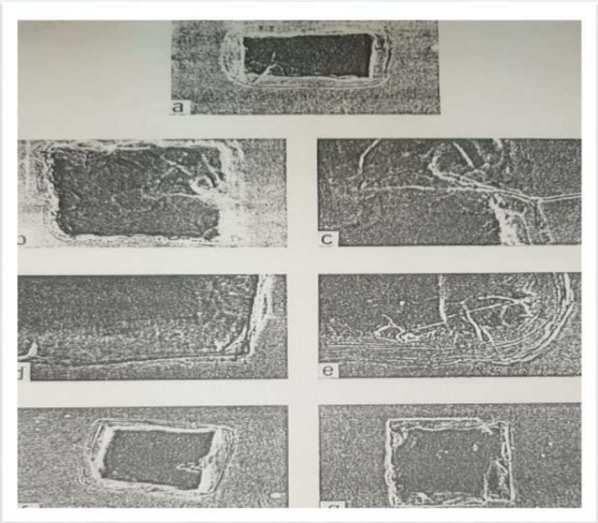

Fig. 1.

a. (67 X),b. (67 X) and c.(133 X). biotite flakes after 8 weeks exposure in cultures of *Aspergillus niger*. Note mycelium penetrating between biotite layers and weathering front near tip of myclium in b and c .

d. (287 X) Biotite from *A.niger* culture.

e. (67 X) Biotite from 15 days in 0.1 M oxalic acid solution at 50^0 C . Note similarity in weathering of flakes in d and e .

f. and g . (67 X). Flakes from soil- inocula cultures derived from soils of yellow poplar(f) and hemlock (g) forests (Heggo, 1978) .

Orthoclase **Muscovite**

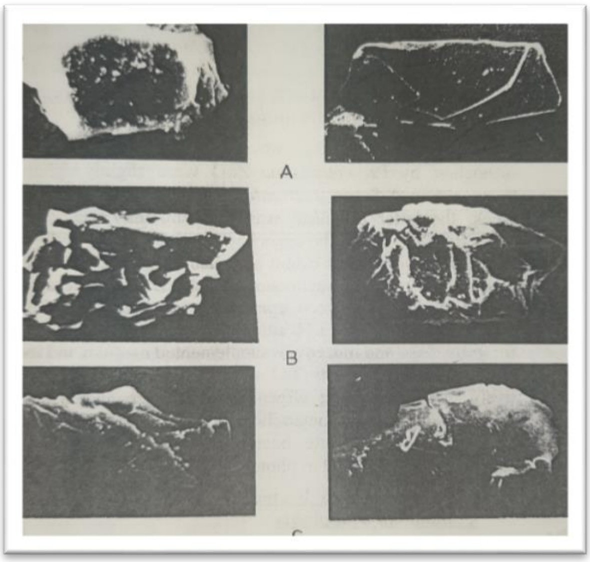

Fig. 2. Morphological changes in orthiclase and muscovite particules indused by biological weathering of silicate bacteria as shown by scanning Electron Microscopy (Heggo, 1978) .

A) Uninoculated control treatment

B) Inoculated with *B.circulans* Ta 1.

C) Inoculated with *Ps.mendocina* Zm3.

A wide range of microbes has been reported to be capable of degrading rocks and minerals, generally through the production of organic acid metabolites. Citric, oxalic and 2-ketogluconic acids were the most active, while fatty acids, tartaric acid, humic, fulvic and lichenic acids were less active (Dacey, *et al*., 1981). In order to determine how subsurface bacteria affect the dissolution rate or rock forming minerals various subsurface isolated were added to silicate mineral slurries and Si release into solution was monitored over time. Gluconate, promoted solution was the predominant mechanism in experiments as gluconate production was a common trial among the isolates capable of enhancing silicate mineral dissolution. These results indicate that bacteria can enhance silicate mineral dissolution and gluconate promoted dissolution was also observed with other silicate minerals such as albite, quartz and kaolinite (Vandevivero, *et al*., 1994). And mixed strains of silicate bacteria were leaching of silicon from bauxite Shoufa, *et al.,* 2013.

Screening of silicate bacteria

Groudev and Gecev (1978) studied the properties of bacteria and the ability to destroy aluminosilicate mineral. They found that the bacteria are unicellular with few exception. The bacterial cell is contained within a rigid or semirigid cell wall conferring a constancy form. Cell multiplication involves growth and division thus causing recognizable arrangement. In fluid environment many species are motile. Endospores are formed by some species under unfavourable conditions. Afify (1982) found that there were differences in the distribution of silicate bacteria; generally their dentisted were higher in the fine-textured than in the coarse textured soils, and three bacterial strains were capable of actively solubilizing orthoclase. They are rod shaped and show capsules which appear in the incident light as shining structure like glass (Fig. 3). Two strains were identified as *Bacillus circulans* and one as *Arthrobacter tumescens (*Fig. 4 and 5). Groudev and Groudeva (1988) reported that bacteria related to the species of *Bacillus mucilaginous* but some strains were ecotypes of varities of the well known soil bacterium *Bacillus circulans*. The cell are rod-shaped and their size is about 1x 5 microns. One or more cells are covered by mucilaginous capsule which is formed on media free of nitrogen. The bacteria rapidly formed spores on media containing nitrogen. The spores were oval shapes with central or subterminal location in the cell. The bacteria are heterotrophic and use different organic compounds as sourses of carbon and energy. They are capable of growing on nitrogen-free media containing silicates or aluminosilicates. The optimum temperature for growth is 35-40^0 C optimum pH is 7.0 but some strains only grow at pH below 5.0.

Fig. 3. Cultural characteristics of colonies of silicate bacteria on Aleksandrov's agar medium (Afify, 1982).

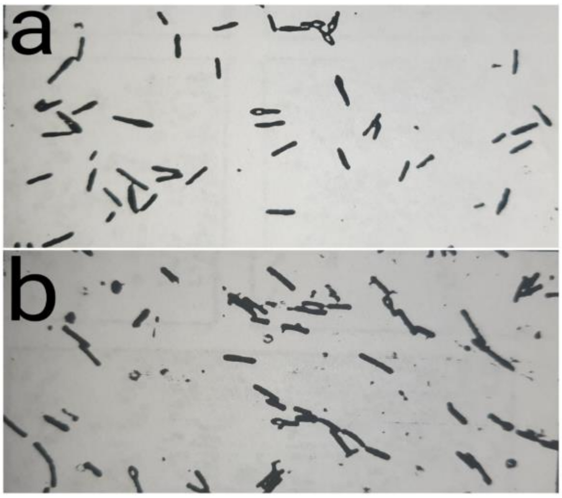

Fig. 4. Morphological characteristics of the two long sporulated rod shaped strains of *Bacillus circulans* under light microscope (Afify, 1982).

(a) *Bacillus circulans* S_1 (b) *Bacillus circulans* S_2

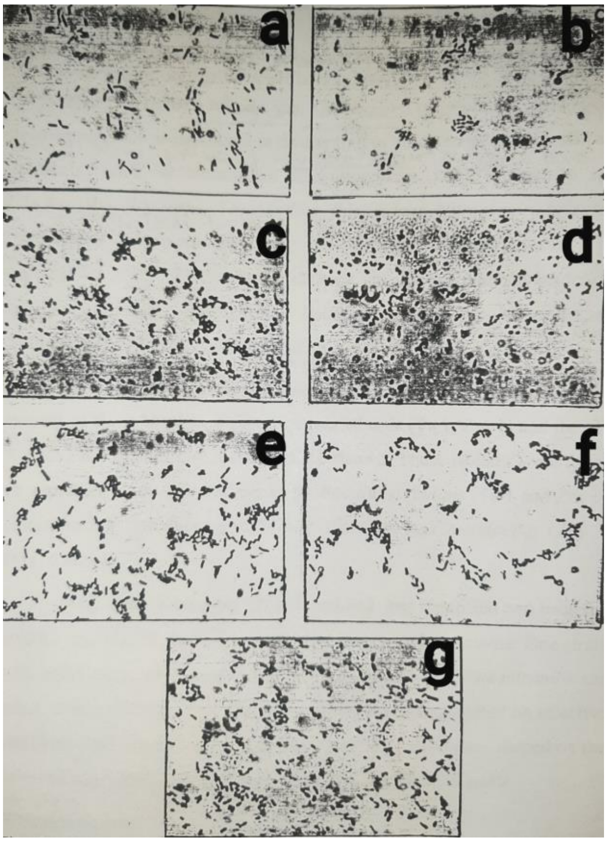

Fig. 5. Morphological changes "pleomorphic shaped" strain of *Arthrobacter tumescens* under light microscope (Afify, 1982)

(a) Culture on nutrient agar plus glucose at 30^0C after 12 (h);
(b) after 72(h);
(c&d) culture on nutrient agar plus yeast extract at 30^0C after 48 (h);
(e&f) culture on nutrient agar plus glucose + yeast extract at 30^0C after 24(h).
(g) and after 36(h); (Notice the coryneform and myceloid growths).

Balabel (1997) observed many purified isolates of silicate bacteria, among of these bacteria are long sporulated rods (Ta I, Zm 1) and the (Ta 1 and Zm3) short non sporulated rod shaped. These isolates were found to represent 4 strains belonging to *Bacillus circulans* (Ta1 and Zm 1), *Entrobacter sakazakki (Ta 1)* and *Pseudomonas mendosina* (Zm 3)(Fig.6 and 7).

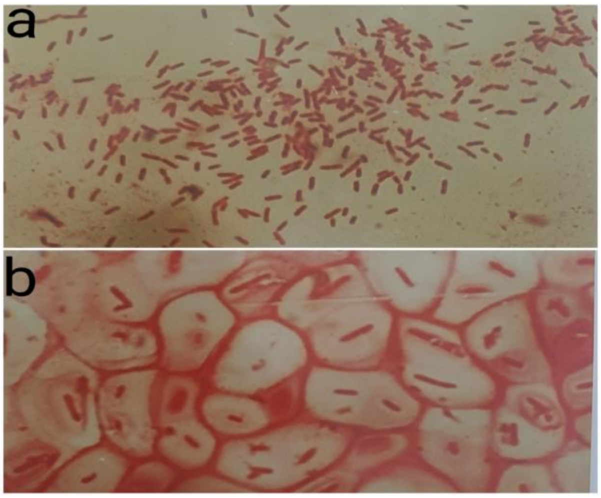

Fig. 6. Morphological characteristics of the two long sporulated rod shaped strains of *Bacillus circulans* under light microscope (Balabel, 1997).

(a) *B.circulacs Ta1.* (b) *B.circulans* Zm1

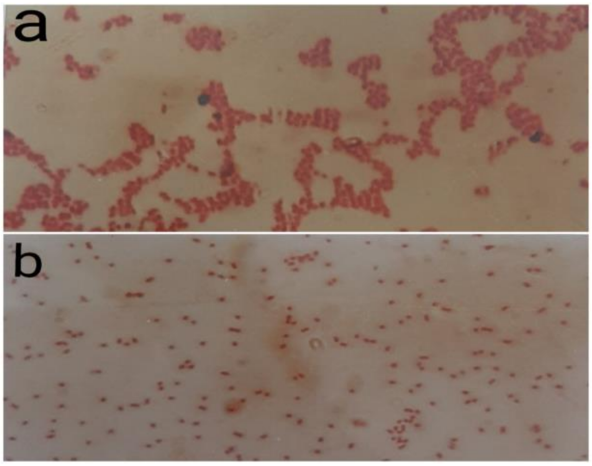

Fig. 7. Morphological characteristics of the two short non-sporulated rod shaped strains of *Enterobacret sakazakii* Ta1 (a) and *Pseudomonas mendocina* Zm3 (b) under light microscope (Balabel, 1997).

Afify and Bayoumy (2001) isolated and identified two bacterial strains capable of actively solubilizing biotite and muscovite. One strain was short rods, non sporulated; and identified as *Proteus mirabilis* and other strain was long sporulated rods in chains, encapsulated on selective medium; and identified as *Bacillus circulans*. Colonies shaped on the selective agar medium were mucous having the shape of a tear. Shoufa *et al*., (2013) found that silicate bacteria generally placed in the species *Bacillus circulans* and *Bacillus mucilaginosus* and *Bacillus edaphtes* can librated silicon from ores. Recantly, according to various studies carried out in the last few decades, certain bacteria capable of silicate solubilization are known, but the phylogenetic distribution is a neglected area in such studies. The bacteria having silicate solubilizing activity are distributed in the phylum Proteobacteria and Firmicutes. Most of the silicate solubilizing bacteria (SSBs) belong to Bacillus, Pseudomonas, Proteus, Enterobacter etc. (Raturi *et al.,* 2021). Up to now several SSBs belongs to diverse genera have been isolated and characterised (Fig. 8). The diverse phylogenetic distribution of the SSB indicates possibility of diverse origin and molecular activity.

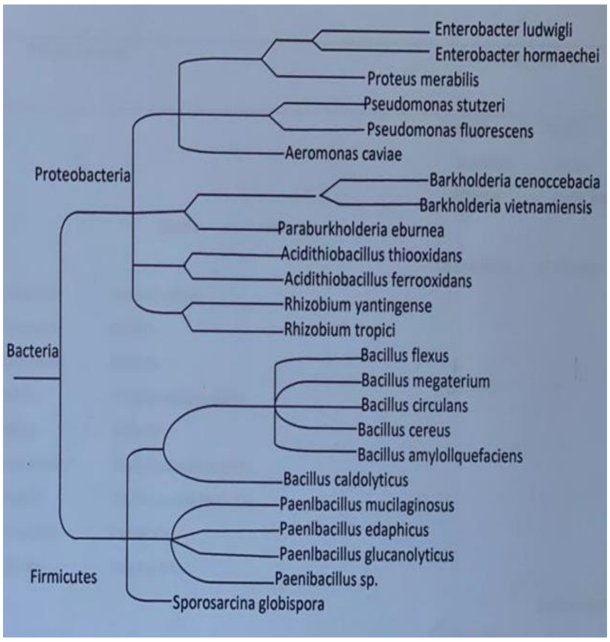

Fig. 8. Taxonomical distribution of silicate solublizing bacteria (SSB). The phylogenetic tree has been prepared by using phyloT tool (https://phylot.biobyte.de/). (Raturi *et al.*, 2021).

Silicate minerals

Morphological, physical, and chemical analyses were carried out on the soils. Mineralogical analyses were also made of sand, silt, and clay fraction by X-ray diffraction and chemical techniques. The clay and fine silt fraction contain interstratified and chemical techniques (mica/hydroxy-interlayered vermiculite in the upper horizons, Kanolinite and gibbsite deminato sub soil horizons). In Fig.(9) study on mineralogy of sand, silt and clay fractions of a few Entisols of West Bengal show that quartz , feldspar and mica are the major silicate minerals in sand and silt fractions. In the clay fractions, the dominant clay mineral is mica in association with minerals like kaolinite, smectite, chlorite, vermiculite, microcline coupled with considerable amount of amorphous mineral. Mica, feldspar and chlorite are considered as partly inherited from parent materials and weathering sequence of mica has been shown. Minerals are in vermiculite weathering stage calculated from weathering means (Adhiraki and Si, 1993).

Primary minerals		Secondary minerals	
		Gerthite	FeOOH
		Hematite	Fe_2O_3
		Gibbsite	$Al_2O_3.3H_2O$
Quartz	SiO_2		
		Clay minerals	Al silicates
Muscovite	$KAl_3Si_3O_{10}(OH)_2$		
Microcline	$KAlSi_3O_8$		
Orthoclase	$KAlSi_3O_8$		
Biotite	$KAl(Mg,Fe)_3Si_3O_{10}(OH)_2$		
Albite	$KAlSi_3O_8$		
Homblende[a]	$Ca_2Al_2Mg_2Fe_3Si_6O_{22}(OH)_2$		
Augite[a]	$Ca_2(Al,Fe)_4(Mg,Fe)_4Si_6O_{24}$		
Anorthite	$CaAl_2Si_2O_8$		
Olivine	$(Mg,Fe)_2SiO_4$		
			$CaCO_3.MgCO_3$
		Dolomite	
		Calacite	
		Gypsum	

[a] The given formula is only approximate since the mineral is so variable in composition.

Fig. 9. Primary and secondary of the silicate minerals (Adhiraki and Si, 1993).

In the study of mineralogy of sand, silt and clay fractions (Fig. 10) showed that quartz, feldspars and micas are the major silicate minerals present in sand and silt fractions. In the clay fractions, the dominant clay mineral is mica (illite) in association with Kaolinite, chlorite, quartz and mixed layer minerals. It was observed that mica was formed by mechanical degradation of the mica flakes and loss of inter layer potassium (Rania, *et al*. 1994).

Mineral Constituent	Origin	Igneous Rock, persentage	Shale, percentage	Stand-Stone, percentage
Feldspars	Primary	59.5	30.0	11.5
Amphiboles and pyroxenes	Primary	16.8	. . .	a
Quartz	Primary	12.0	22.3	66.8
Micas	Primary	3.8	. . .	a
Titanium minerals	Primary	1.5	. . .	a
Apatite	Primary and Secondary	0.6	. . .	a
Clay	Secondary	. . .	25.0	6.6
Limonite	Secondary	. . .	5.6	1.8
Carbonates	Secondary	. . .	5.7	11.1
Other minerals	. . .	5.8	11.4	2.2

Fig. 10 Average Mineralogical Composition of Igneous and Sedimentary Rocks (Rania,1994).

Most clay minerals are aluminosilicates, the major elements in their structure being oxygen, silicon, and aluminum. Aluminoailicate clay minerals are divided into groups based on the number of sheets of Si tetrahedra and Al octahedra in their layers by the incorboration of "accessory" cations in addition to silicon. With further oxygen-sharing, silica tetrahedra from the basic sheet structure of the layer silicates (Fig. 11). Readily visible examples are the mica minerals, of which muscovite, white mica, and biotite, black mica. The mica minerals of ten weather directly into clay minerals.Quartz and the feldspars are the most important examples of minerals with a continuous silicate structure. Quartz is SiO_2. All the bonds are Si-O, and there is no need for accessory cations to balance the charge, therefore it is hard and durable. The basic structure of the feldspar group is a three-dimensional structure like quartz. However, in addition to Si, the feldspars have Al^{+3}, balanced by Na^+, K^+ or Ca^{2+} as accessory cations. The two most common group of feldspar minerals are orthoclase and plagioclase. Feldspars are more weatherable than quartz because of the K,Na and Ca needed to balance the charge. They are a source of these plant nutrients (Singer and Munns1999).

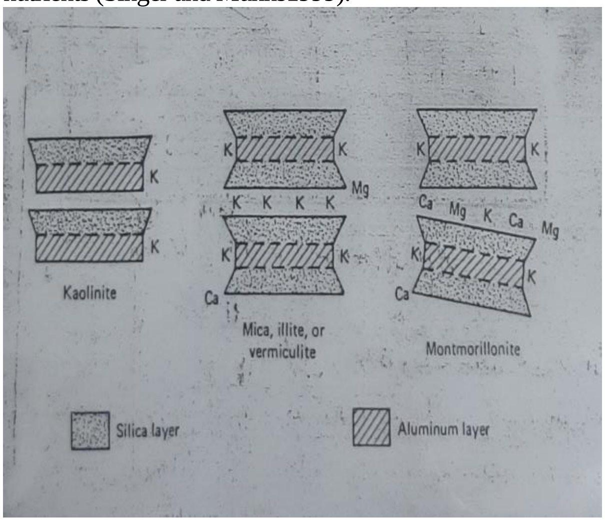

Fig. 11. Layers of alumino silicate and accessor cations (Singer and Munns 1999).

Dynamics of potassium, silicon and aluminium

The bulk of mineral elements in the alumino-silicates consist of the three: potassium, silicon, and aluminium. Therefore, the degradation of such silicate minerals will eventually release potassium, silicon and aluminium.

Potassium

Form of potassium in the soil

Diest (1978) described simply,the behavior of potassium in soil , in summary fashion by the following scheme: K non exchangeable ==== K exchangeable ⇌ k in soil solution ⟶ K in plant. The scheme indicates that the reaction between the solution and solid phases are reversible, suggestion that the soil minerals can function as both sourses and sinks for k.

Soil potassium is generally believed to exist in four categorie depending upon their availability to crops. These categories in increasing order are: mineral K in structural; nonexchangeable K (fixed or difficulty available); exchangeable K; and solution. Soil solution potassium and exchangeable potassium are readily available but in most soils they represent only less than 1% (Tisdale *et al*., 1985 and Brady, 1990). The relative proportions of the total soil potassium in unavailable, slowly available and readily available forms could be diagrammatically presented (Fig.12) as follows:

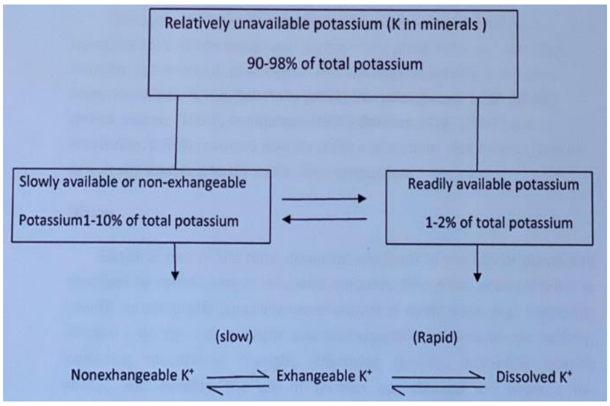

Fig. 12. Equilibrium relationships among the three divisions of potassium ions in soils.

Potassium combined in minerals is found predominantly in "primary" and "secondary" crystalline silicates. The K in micas, biotite (at 3.8%) is more abundnt than muscovite (1.4%) and in feldspars their general formula being K Al Si_3 O_8, according to which the theoretical K content is 14%. Also, the potassium containing micas are, like fildspars, potassium aluminosilicates, but their composition is more complex. They are phyllosilicates and contain along with the Si tetrahedra Al octahedra with varying subsitution of the central ions. The K content of muscovite should theoretically be 9.8% and that of biotite 8.7% (Schroeder,1978). There are factors affecting the availability of potassium in soils, both microbiological and chemical factors can influence the availability of soil K as well (Diest, 1978). The author reported that pH affects K fixation, but the influence is in indirect, in that pH largely determines which cation predominates in the inter-layer position of clay minerals. He also, demonstrated that good aeration favours both root extension and the functioning of uptake mechanisms in the root responsible for the selective with drawal of K. The influnce of soil moisture upon the availability of K was reviewd by Grimme (1976). He reported that the importance of aeration for K uptake by the root, it will be clear that there is a limit to the extent to which increasing moisture content will improve the K nutrition of plants.

Role of potassium (k) on plant growth

The roots of higher plants absorb k from the soil as K^+ and this is translocated to all the tissues and organs of the plant. Thus, K^+ becames available at the sites of physioligical and biochemical activity in the plant. Many investigators, e.g. Yali-Halla (1992); Barraclough and Leigh (1993); Linna& Jnsson, (1994); Kemppinen (1995); Baikken *et al.,* (1997) and Passikallio, (1999) reported that the biotit a potassium- rich mineral, is used as a slowly soluble K fertilzers for plant production.

Silicon

Silicon is one of the most dominant elements in the ash of plants and absorbed by certain ones in very large amounts. Silicon has been reported to benefit certain plants (especially cereal plants) in many ways, e.g., improving efficiency of the use sunlight and consequently photosynthetic activity, increasing mechanical strength, improving fertility, increasing tillering ability… etc. Besides, the use of silicates was claimed to improve the efficiency of phosphate utilization. Silicon is the most abundant element in the Earth's crust, comprising about 27% of it (Fig.13).

Excluding carbon and oxygen, silicon represents 70% of soil elements. In nature, it always occurs in combination with other elements, especially with oxygen and various metals in clay minerals (Troeh and Thompson, 1993).

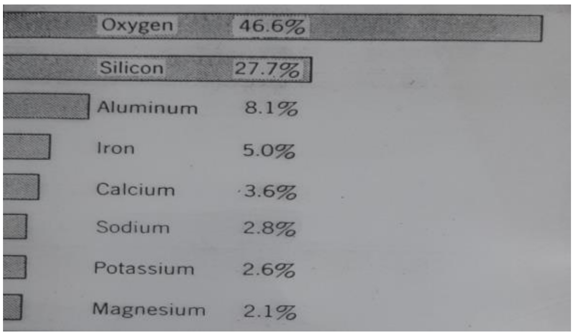

Fig. 13. The eight elements in earth's crust comprising over 1 present by weight. The remainder of elements make up 1.5 present (Troeh and Thompson, 1993).

Chemical forms of silicon in plants

Maxwell *et al.,* (1972) noted that polymerized silicic acids in the rice plant are strongly bound to cellulose forming a silicocellulose membrane and can only be separated after the cellulose is dissolved. Silicon forms crystals of plant opal (Fig. 14). These crystals are commonly elongated and serve to strengthen the stems of plants.

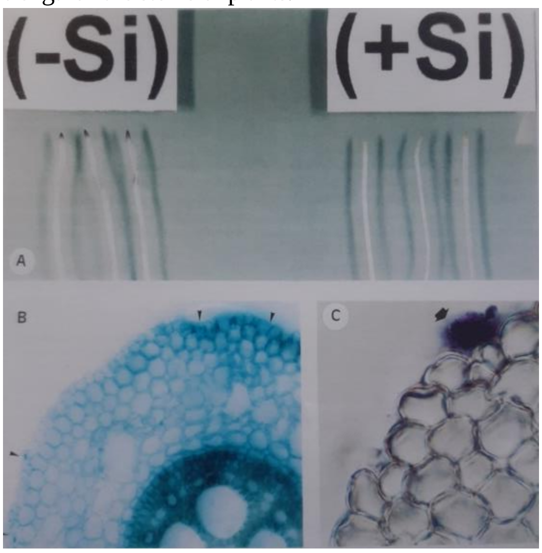

Fig. 14. (A) Hematoxylin staining of root tips of plant from Experiment 1, pretreated with (+Si) or without (-Si) 1mM Si for 72h and then exposed for 24 h to solutions without Si containing 50 µM Al. (B,C) Hematoxylin staining of free hand sections of mature root zones of Si . (B) and +Si (C) plants exposed to 50 µM Al (Maxwell *et al.,* 1972).

Silicon is important element for "improved growth " of a wide varietly of plant species for both monocotyledons and dicotyledons. Various symptoms appeared when silicon was absent or present in only small amounts. Effects of silicon on plant could be grouped into three categories: (a) Effects on soil, (b) Effects on plants and (c) Effects on resistance of plants to insects and diseases.

(a) Effects of soil: Silicon plays some parts in the synthesis of humic matter. The benefits could be obtained by applying silicate materials to the soil, increseed cation exchange capacity by increasing net negative charge and increased soil calcium and magnesium levels and soil pH when calcium silicate is applied (Troeh and Thompson 1993).

(b) Effects of plants: Beneficial elements have significant influnce on plant growth even though they have not been shown to be vital for completing the life cycle. Such elements as silicon, sodium, rubidium, cobalt, and vanadium may be called functional or benefical rather than essential. Crops differ considerably in the amount of silicon they take up. Grasses and cereals normally have over 1% of SiO_2in their dry matter(Russel,1973) and increase SiO_2 in barley (Afify , 1982). Further research, of course, may add some of them to the list of essential micronutrients (Troeh and Thompson 1993).

(c) Effects on resistance to diseases: Application of silicon combines to the soil has been reported to increase the resistance is related to the silicon content of the plant, particularly the leaves (Mark *et al.,* 1997).

Aluminium

Aluminium is the most abundant element after oxygen and silicon in the Earth's crust and in the majority of rocks and soils (Fig. 13). The aluminum content of soil, expressed on the basis of Al_2O_3. Frequently is in the range of about 6%. Most rocks and soil minerals can be considered as essentially a systematic arrangement of oxygen anions with various cations (mostly silicon and aluminium) in the holes between. Minerals having frameworks of oxygen and silicon are called silicates; silicates that include aluminum in their frameworks are called aluminosilicates. Therefore, aluminum occurs mainly in the aluminosilicate minerals, feldspars, pyroxens and layer silicates (Singer and Munns 1999).

Aluminium in plants

Hinsinger *et al.,* (1993) showed that rape can acidify its rhizosphere to PH under 4.5 after 32 days of cultivation and mobilize its constituent elements of the crystal lattice of phyllosilicates, Al in particular. Silicon aluminium uptake seems to be decreased, mainly because of the formation of Al-Si complexes in the growth substrate, leading to lower Al availability (Baylis *et al.,* 1994). However, there are several reports which suggest that Al-Si interactions within plants may also play a role Hodson and Evans (1995).

Application of slicate bacteria as biofertilizers

The role of such bacteria in the decomposition of alumino-silicates and releasing the elements contained therein as well as in the elements uptake by plants was found of great interest. In this respect, the silicate-dissolving bacteria are capable of production organic acids which change structural building of silicate and release unavailable elements into the soil solution. Therefore, this microbial action as a means for releasing nutrients for plant uptake and decreasing the use mineral fertelizers has recently received attention for increased profitability and crop production potential. Aleksandrov and Zak (1950) isolated a strain of *Basillus siliceus* from soil which was capable of decomposing aluminosilicates and relea. Aleksandrov *et al.,* (1962) noted that bacteria related to *Bacillus circulans* and *Bacillus mucilaginosus* frequently increase the yield of agricultural crops by 30-35 %. Aleksandrov and Ternov's (1963) studied the effect of inoculation with silicate bacteria on a great number of winter crops in four experiments using various of methods bacterization. The results showed an average increase in grain yield of 17%.

Aleksandrov and Segodina (1970) pointed out that the bacterization of seeds causes a number of significant changes in soil as follows: 1) increasing the supply of nitrogen, phosphorus, and potassium compounds available to plant through out the entire vegetation period ;2) increasing the yield of agricultural crops ;3) decreasing morbidity of the plant.In china, Li-ZhenGeo *et al* ., (2000) reported that microbial fertilzers and inoculants are improve soil quality , the quantity yield and protien of plants. Cheng *et al* 2002 noted that the silicate bacteria are very important in recent times because of their role in solubilisation of of silicate minerals rendring silica and potassium available for crop uptake thus reducing the potash fertilizer requirement.

Recantly, Vasanthi *et al*., (2013) suggested that silicate solubilizing bacteria(SSB) are used as biofertilizer to plants as it solubilizing silica and potassium from soil silicate minerals. Generally, in many countries such as: Russian, China and USA a great deal of researches were conducted on the role of microorganisms in mobilizing potassium, silicon and aluminium represented by a group of bacteria given the name silicate bacteria. Led to a preparation of biofertilizer called "Silico-bacterin" which proved to be capable of decomposing aluminosilicate minerals and solubilizing elements their contents to available form for the growing plants. In advanced technology, slow-release fertilizers have been one of the main research targets. One of the most realistic hopes for increasing the amounts of biologically mobilized potassium and silicon for agriculture is to inoculate seeds or soil with superior strains of silicate bacteria "silicobacterin" as a slow-release fertilizer.

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بكتيريا السليكات كسماد حيوى

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الملخص

تعتبر تجوبة المعادن جزء من تركيب الأرض وهذا يتم فى المعادن الألومينوسليكاتية (الطينية). حيث تحتوى هذه المعادن على بعض العناصر مثل: البوتاسيوم و السليكون و الألومنيوم و تكسير وتحليل هذه المعادن الألومينوسليكاتية تزيد من هذه العناصر ومن عوامل التعرية البيولوجية لهذه المعادن هى الكائنات الحية الدقيقة التى تسمى بكتيريا السليكات حيث تقوم هذه البكتيريا بتحليل المعادن و خاصة السليكاتية و بالتالى تزيد من العناصر مثل : البوتاسيوم والسليكون والألومنيوم و تكون فى صورة ميسرة . وبذلك نجد أن الدور الفعال لمثل هذه البكتيريا هو تحليل المعادن الألومينو سليكاتية و زيادة هذه العناصر فى التربة و تجعلها فى صورة ميسرة للنباتات. لذا تعتبر هذه البكتيريا من عوامل التسميد الحيوى فى التربة و أيضا تعمل على تقليل التلوث البيئى بالأسمدة الكيماوية .